CLAIMS

1. A planar lightwave circuit having a core and a clad which are formed on a substrate, characterized by comprising:

at least one input optical waveguide which inputs signal light;

mode coupling means for coupling a fundamental mode which is part of the inputted signal light, to at least either of a higher-order mode and a radiation mode, or mode re-coupling means for re-coupling at least either of the higher-order mode and the radiation mode to the fundamental mode; and

at least one output optical waveguide which outputs signal light;

said mode coupling means or said mode re-coupling means being an optical waveguide which has at least one of a core width and height varied continuously.

2. A planar lightwave circuit as defined in claim 1, characterized in that the variation of at least one of the core width and height of the optical waveguide is within ±8 μm per unit length (1 μm) in a propagation direction of the signal light.

3. A planar lightwave circuit as defined in claim 1 or 2, characterized in that said mode coupling means

or said mode re-coupling means is an optical waveguide which has at least one of the core width and height made zero partly.

4. A planar lightwave circuit as defined in any of claims 1 through 3, characterized in that at least one of said mode coupling means and said mode re-coupling means includes at least one insular core portion which is spaced from the core of said optical waveguide.

5. A planar lightwave circuit as defined in any of claims 1 through 4, characterized in that at least one of said mode coupling means and said mode re-coupling means includes at least one insular clad portion having a refractive index equal to that of the clad, within the core of the optical waveguide.

6. A planar lightwave circuit as defined in any of claims 1 through 5, characterized in that the substrate is a silicon substrate, and that the core is of silica-based glass.

7. A planar lightwave circuit including an optical waveguide lens which has a core and a clad formed on a substrate, characterized in:

that the optical waveguide lens comprises:

at least one input optical waveguide which inputs

signal light;

mode coupling means for coupling part of the inputted signal light to a higher-order mode and a radiation mode;

mode re-coupling means for re-coupling the signal light coupled to the higher-order mode and the radiation mode by said mode coupling means, to output signal light; and

at least one output optical waveguide for outputting the output signal light;

said mode coupling means and said mode re-coupling means being optical waveguides each of which has at least one of a core width and height varied continuously.

8. A planar lightwave circuit including a cross waveguide in which at least two optical waveguides having a core and a clad formed on a substrate cross, characterized in:

that the cross waveguide comprises:

at least two input optical waveguides which input signal light;

mode coupling means for coupling part of the inputted signal light to a higher-order mode and a radiation mode;

mode re-coupling means for re-coupling the signal light coupled to the higher-order mode and the

radiation mode by said mode coupling means, to output signal light;

at least two output optical waveguides which output the output signal light, and

an optical-waveguide crossing portion being a part at which two virtual optical waveguides rectilinearly extending from the input waveguides toward the output waveguides overlap;

said mode coupling means and said mode re-coupling means being optical waveguides each of which has a core width varied continuously;

said optical-waveguide crossing portion being such that a core width of an optical waveguide at a position between an end of said optical-waveguide crossing portion on a side of said input optical waveguides and a central part of said optical-waveguide crossing portion is greater than the core width of the optical waveguide at an end of said optical-waveguide crossing portion on the side of said input optical waveguides and the core width of the optical waveguide at the central part of said optical-waveguide crossing portion, and that the core width of the optical waveguide at a position between the central part of said optical-waveguide crossing portion and an end of said optical-waveguide crossing portion on a side of said output optical waveguides is greater than the core width of the optical waveguide

at the central part of said optical-waveguide crossing portion and the core width of the optical waveguide at the end of said optical-waveguide crossing portion on the side of said output optical waveguides.

9. A planar lightwave circuit including an optical branch circuit which has a core and a clad formed on a substrate, characterized in:

that the optical branch circuit comprises:

one input optical waveguide which inputs signal light;

mode coupling means for coupling part of the inputted signal light to a higher-order mode and a radiation mode;

mode re-coupling means for re-coupling the signal light coupled to the higher-order mode and the radiation mode by said mode coupling means, to output signal light; and

at least two output optical waveguides which output the output signal light;

said mode coupling means and said mode re-coupling means being optical waveguides each of which has a core width varied continuously.

10. A planar lightwave circuit including a slab type coupler which has a core and a clad formed on a substrate, characterized in:

that the slab type coupler comprises:

at least one, first input/output optical waveguide which inputs/outputs a light signal;

an optical slab waveguide which is optically connected to the first input optical waveguide; and

at least two, second input/output optical waveguides which are optically connected to said optical slab waveguide, and which input/output light signals; and

that said second input/output optical waveguides comprise mode coupling means for coupling part of the inputted/outputted signal light to at least either of a higher-order mode and a radiation mode, and converting the coupled part into a plane wave at an end of said optical slab waveguide;

said mode coupling means being an optical waveguide which has a core width varied continuously.

11. A planar lightwave circuit including an arrayed waveguide grating filter which has a core and a clad formed on a substrate, characterized in:

that the arrayed waveguide grating filter comprises:

at least one input optical waveguide which inputs signal light;

a first optical slab waveguide which is optically connected with said input optical waveguide;

arrayed optical waveguides which are optically connected with said first optical slab waveguide, and which become longer with a predetermined waveguide length difference in succession;

a second optical slab waveguide which is optically connected to said arrayed optical waveguides; and

at least one output optical waveguide which is optically connected to said second optical slab waveguide; and

that each of said arrayed optical waveguides comprises:

mode re-coupling means for re-coupling a higher-order mode and a radiation mode to the signal light, at a part optically touching said first optical slab waveguide; and

mode coupling means for coupling the signal light to the higher-order mode and the radiation mode, at a part optically touching said second optical slab waveguide;

said mode coupling means and said mode re-coupling means being optical waveguides each of which has a core width varied continuously.

12. A method wherein a wave propagation circuit for obtaining a desired output field from an input field is designed by employing a computer, characterized by

comprising:

a refractive-index-distribution initialization step of storing initial values of a refractive index distribution of a propagation medium in the wave propagation circuit, in storage means of the computer;

a step of setting any position of the transmission medium in a wave propagation direction thereof, as an optimized position;

an optimized-position input/output-field computation step of computing a field in a case where the input field has propagated forwards from an inlet of the wave propagation circuit to the optimized position, and a field in a case where the desired output field has propagated backwards from an output of the wave propagation circuit to the optimized position, and then storing the fields in the storage means of the computer; and

a refractive-index-distribution alteration step of adjusting the refractive index distribution at the optimized position so that wavefronts of the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards may agree;

the optimized-position setting step, said optimized-position input/output-field computation step and said refractive-index-distribution alteration step being iterated while the optimized position is being

changed in the wave propagation circuit.

13. A method wherein a wave propagation circuit for obtaining a desired output field from an input field is designed by employing a computer, characterized by comprising:

a refractive-index-distribution initialization step of storing initial values of a refractive index distribution of a propagation medium in the wave propagation circuit, in storage means of the computer;

a step of setting an outlet of the wave propagation circuit as an optimized position;

a forward-propagation input-field-distribution computation step of computing a field distribution in a case where the input field has propagated forwards from an inlet of the wave propagation circuit to the output thereof, and storing the field distribution in the storage means of the computer;

a backward-propagation optimized-position output-field computation step of computing a field in a case where the output field has propagated backwards from the outlet of the wave propagation circuit to the optimized position, and storing the field in the storage means of the computer; and

a refractive-index-distribution alteration step of adjusting the refractive index distribution at the optimized position so that wavefronts of the field in

the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards may agree;

said backward-propagation optimized-position output-field computation step and said refractive-index-distribution alteration step being iterated while the optimized position is being successively changed from the outlet to the inlet along a wave propagation direction.

14. A method wherein a wave propagation circuit for obtaining a desired output field from an input field is designed by employing a computer, characterized by comprising:

a refractive-index-distribution initialization step of storing initial values of a refractive index distribution of a propagation medium in the wave propagation circuit, in storage means of the computer;

a step of setting an inlet of the wave propagation circuit as an optimized position;

a backward-propagation output-field-distribution computation step of computing a field distribution in a case where the output field has propagated backwards from an outlet of the wave propagation circuit to the input thereof, and storing the field distribution in the storage means of the computer;

a forward-propagation optimized-position input-

field computation step of computing a field in a case where the input field has propagated forwards from the inlet of the wave propagation circuit to the optimized position, and storing the field in the storage means of the computer; and

a refractive-index-distribution alteration step of adjusting the refractive index distribution at the optimized position so that wavefronts of the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards may agree;

said forward-propagation optimized-position input-field computation step and said refractive-index-distribution alteration step being iterated while the optimized position is being successively changed from the inlet to the outlet along a wave propagation direction.

15. A method wherein a wave propagation circuit for obtaining a desired output field from an input field is designed by employing a computer, characterized in:

that the adjusted refractive index distribution which is obtained by performing the design method for the wave propagation circuit as defined in any of claims 12 through 14 is set as the initial values of the refractive index distribution at said refractive-index-distribution initialization step in either of

the methods defined in claims 13 and claim 14, so as to perform the method defined in either of claim 13 and claim 14; and

that the adjusted refractive index distribution which is obtained by performing either of the methods defined in claim 13 and claim 14 is set as the initial values of the refractive index distribution at said refractive-index-distribution initialization step in the other method, so as to alternately iterate the methods defined in claim 13 and claim 14.

16. A method as defined in any of claims 13 through 15, characterized in that the input field and/or the desired output field includes a plurality of wavelengths.

17. A method as defined in any of claims 12 through 16, characterized in that said refractive-index-distribution alteration step is a step of giving refractive indices each of which is proportional to a phase difference between the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards, in at least some of the optimized positions.

18. A method as defined in any of claims 12 through 16, characterized in that said refractive-index-distribution alteration step is a step of distributing a core and a clad layer in accordance with a phase difference between the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards, in at least some of the optimized positions.

19. A method as defined in claim 18, characterized in that said step of distributing the core and the clad layer is a step of distributing the core in a place where the phase difference is greater than a real number T greater than zero, and distributing the clad layer in a place where the phase difference is smaller than the real number T, in at least some of the optimized positions.

20. A method as defined in claim 18 or 19, characterized in that said step of distributing the core and the clad layer distributes the core and the clad under a limitation that a size of the core becomes on the order of a wavelength of a wave, in at least some of the optimized positions.

21. A method as defined in any of claims 18 through 20, characterized in that said step of distributing

the core and the clad layer distributes the core and the clad layer under a limitation that the core is distributed or removed at only a boundary part between the core and the clad layer.

22. A method as defined in any of claims 12 through 21, characterized in that the field computation step or the field-distribution computation step is any of a beam propagation method, a finite difference time domain method, and a mode matching method.

23. A computer program characterized by executing the method as defined in any of claims 12 through 22.

24. A computer-readable storage medium characterized by storing therein the computer program as defined in claim 23.